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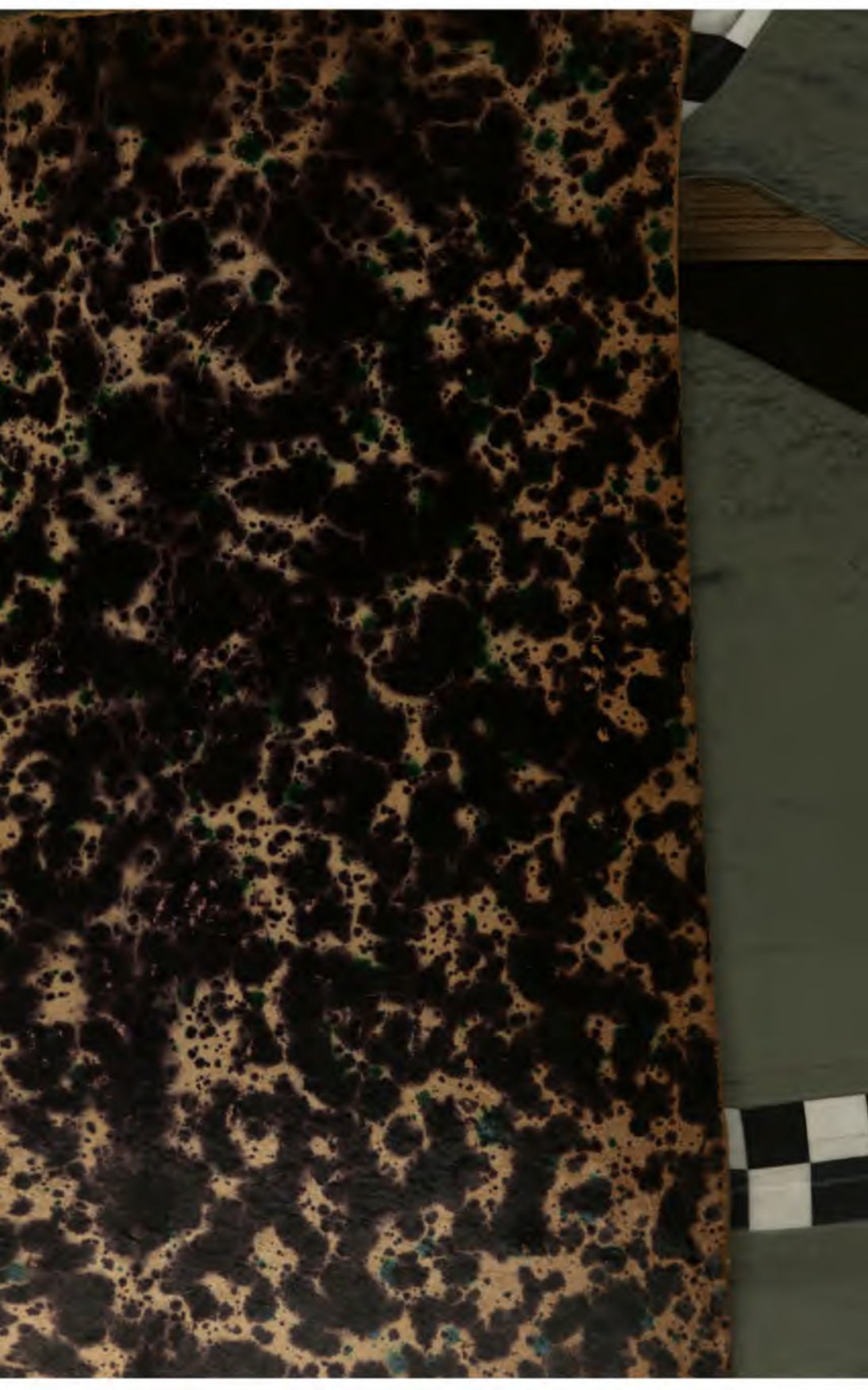
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SCIENTIFIC AND INDUSTRIAL
EDUCATION IN THE UNITED STATES.

Cornell

AN ADDRESS

DELIVERED BEFORE THE

NEW-YORK STATE AGRICULTURAL SOCIETY.

BY

ANDREW D. WHITE, LL.D.,

PRESIDENT OF CORNELL UNIVERSITY.

[REVISED BY THE AUTHOR FOR THE POPULAR SCIENCE MONTHLY.]

NEW YORK:
D. APPLETON AND COMPANY,
549 AND 551 BROADWAY.
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SCIENTIFIC AND INDUSTRIAL EDUCATION IN THE UNITED STATES.¹

By ANDREW D. WHITE, LL. D.,
PRESIDENT OF CORNELL UNIVERSITY.

A LITTLE more than two hundred years ago, in England of the Roundheads and Cavaliers, a voice was raised to propose that young men receive instruction bearing on the various national industries. He who proposed this was a man of great genius—one of the true priests and prophets of his time. He foresaw and foretold many great modern inventions, and among them the steam-engine. His brain helped to think out its principles, his hands helped to shape its groundwork. With pen and tongue he sought to promote the “new education;” but he had fallen on evil times. With Strafford and Laud on one side, and Hampden and Cromwell on the other, there was but poor hearing for the industrial ideas of the Marquis of Worcester. Persecuted, maligned, and a bankrupt, he died, and, to all appearance, his idea died with him. For two centuries afterward Oxford and Cambridge solemnly ground out the old scholastic product in the old scholastic way.

About fifty years ago, a body of the best scholars and thinkers in England made another attempt. Their endeavor was, to found an institution giving an education fitted to the needs of their land and time. They established the University of London. Never had a plan more brilliant advocates. Brougham, Sydney Smith, and Macaulay, spoke and wrote for it; but their success was small. The institution was unsectarian, therefore the Church declared against it as “godless;” it gave instruction in modern learning as well as in ancient learning, therefore the great body of solemn scholars declared it unsound; some of its ideas and methods were new, therefore a multitude of leaders of society declared it unsafe. The institution was kept down, and from that day to this has never taken the high place to which its plan and work entitled it.

About thirty years since, the strongest man who has ever stood in an American college presidency made an effort in the same direction. Francis Wayland knew what there was of good in the old scholarship and was loyal to it, but he saw that new times make new demands, and he planned out and endeavored to work out a system of education which should meet these demands. All to no purpose. It was the old, old story—another great man, with his great idea, as Carlyle phrases it, “trampled under the hoofs of jackasses,” or, as Wayland himself phrased it more mildly, “nibbled to death by ducks.”

Various minor attempts were made—some of them, like Eaton's noble effort at Troy, very fruitful; but no general plan, no large institution was created worthy of the great interest involved.

About five years later, Mr. Lawrence, of Massachusetts, a thoughtful manufacturer, made another attempt. He saw the necessity of education bearing on the great industries of the country, and made to Harvard College what in those days was called a princely gift. Thus was founded the “Lawrence Scientific School,” at Cambridge, and thus did industrial studies get their first foothold in a great university.

About five years later still, Mr. Sheffield, of Connecticut, also a thoughtful business-man, recognized this great necessity. By a generous donation he founded the “Sheffield Scientific School” at Yale College, and thus these studies got foothold at a second great university.

So much, then, was gained. Some few of the studies bearing on the great modern industries had been taken under the care of great university corporations; but there was one drawback. In neither of these universities were the new studies received into full fellowship with the old. The Scientific School was kept very distinct from the “College proper.” Buildings, courses, and studies, were kept well apart; the student in the sciences was not considered the equal of the student in “the classics.” The student preparing for an industrial profession was not considered as of the same caste with the student preparing for a “learned profession.” He lived in a different building, had lectures and recitations in different rooms, was instructed by different professors, was graduated at a different time and place. He was not considered as properly of the graduating class of his year. Ask any Yale or Harvard man for the names of his classmates, and it never occurs to him to mention the graduates of his year from the scientific departments. Nay, whether it was that young men taking scientific studies were considered as *ipso facto* lost souls, or as having no souls to be saved at all, they were not admitted to the students' seats at the college chapel—they were practically held as of an inferior order.

The next step was made at the State University of Michigan. Here, for the first time in a university, a student in general or industrial science was admitted to full equality with a student in classics.

So far as their studies were the same, they sat in the same rooms, heard the same lectures from the same professors, were admitted to the same chapel, received their degrees at the same time and place, went through the same ceremonies, and stood as equals on the roll of graduates.

Still the provision for industrial education was wretchedly meagre. Other nations had meanwhile shot far ahead of our own in this respect. Germany, France, and even England, had been aroused. They had recognized the fact that the greatest warfare of the nineteenth century is industrial warfare—the struggle between great nations for supremacy in the various industries, and for the control of the various markets. France had developed magnificently her system, putting nearly half a million dollars into a collection of models for the School of Arts and Trades alone. Germany had established a multitude of "*Real Schulen*," and of Technical and Agricultural Colleges. England was already making preparations for her great institution at South Kensington, on which she has lavished millions.

But, just as our great rebellion was drawing on, an attempt was made in the Congress of the United States. Years before, that pure and great man, Dr. Channing, had urged that the proceeds of the sales of public lands be consecrated to the education of the people. An attempt was now made; but, though the good sense of Congress carried a bill, it was vetoed by James Buchanan. But the friends of the measure still pressed on. A chorus of optimists, pessimists, sham economists, holdbacks, and do-nothings, opposed the measure; but a true statesman led the army of education. Justin S. Morrill, of Vermont, stood then as now in the United States Senate. Let his name be long remembered. Statues shall be erected to him long after the little great men who tried to thwart him are forgotten. The bill was passed, and it was signed by Abraham Lincoln.

I ask you now to look a moment at the passage of that bill. Centuries hence men shall look back upon it as one of the noblest things in American annals. Why?

My friends, have you forgotten those days, their discouragements, their forebodings, the morning beginning with "would God it were evening," and the evening ending with "would God it were morning?" It was the darkest hour since Valley Forge; lives, laws, family ties, treasure—all seemed cast into the abyss—and the abyss ever growing wider, and deeper, and blacker—and yet, while the American Congress was providing for the most tremendous home policy, and carrying on the most difficult foreign policy of modern times, they found leisure to plan and carry out a great, comprehensive, and far-reaching system of national education.

Gentlemen, it was one of the great glories of Rome in its best days that its statesmen did not despair of the Republic in its blackest hours. Nay, when a victorious Carthaginian army was encamped

on Roman soil, so great was Roman faith in Roman destiny, that the very soil at that moment trampled by enemies' feet was sold at auction and bought by competition. But here was greater faith; here was nobler patriotism. While the windows of the Senate-house were rattling with the enemy's cannon, those men had such faith in the destiny of the nation, and such trust in the arts of peace, that they quietly and firmly legislated into being this great, comprehensive system of industrial and scientific education. In all human annals I know of no more noble utterance of faith in national destiny out from the midst of national calamity.

But what was this measure?

The question is pertinent, and all the more so now, on account of sundry efforts to misrepresent it. Look at the act of Congress itself. You see at once that it did not provide simply for agricultural colleges, nor simply for colleges of the mechanic arts. No; the intention was broader and deeper than that. It provided that "subjects relating to agriculture and the mechanic arts" should be made "leading branches," "without excluding other classical and scientific branches," and including "military tactics."

What, then, was the purpose? It was to provide fully for an industrial, scientific, and general education suited to our land and time—an education in which scientific and industrial studies should be knit into its very core, while other studies should also be provided for. And, besides this, as it had been seen that the States in rebellion had gained great advantage from the military education of students, it was declared that "instruction in military tactics shall also be included."

The act of 1862 was, then, a noble, comprehensive scheme, looking, as you see, first of all, at the industries of the nation, but at the same time insisting on provision for the broadest scientific and general culture.

I pass now to the reception of the benefits of the act by the various States.

Under the law, land-scrip was given the different States, based upon the representation of each State in Congress, scrip for thirty thousand acres being issued for each representative and senator. You will note here, in passing, one more provision showing thoughtful statesmanship. It was provided that, except in the case of States having public lands within their own borders, *no State should "locate" the scrip*. The great majority of the States could not, therefore, obtain *land*. They could only take the scrip and sell it at market prices. An individual might buy the scrip and locate it; a State could not. Thus was prevented any troublesome *imperium in imperio*, such as would have been created, for example, had the State of New York been allowed to acquire a million of acres in the heart of the State of Wisconsin.

The various States accepted the scrip, and in almost all cases sold it at low prices, the market being glutted; and with the proceeds each established its institution under the act as its interests demanded, or as the money realized permitted.

Note now another important fact. Some States—as Connecticut, Rhode Island, and New Jersey, where the fund was too small to establish a separate institution—gave it for the endowment of scientific and industrial education in an existing institution. Connecticut gave her share to Yale, Rhode Island gave hers to Brown, New Jersey gave hers to Rutgers, New Hampshire gave hers to Dartmouth.

States which received a larger share—but still not enough to carry out the act in all its parts—gave theirs to purely agricultural colleges. Of these were Michigan and Iowa. Others, with a larger share, divided theirs between an institution for agricultural and an institution for technical instruction. Of these were Massachusetts and Missouri. A few which received the largest share determined to carry out the act in its whole scope by founding a single institution, in which industrial and scientific education should be united to general instruction and culture. Of these were Illinois and New York.

It may appear to some that this difference in modes of carrying out the act in the different States was a misfortune. Far from it. I am prepared to maintain, against all comers, that, of all the good fortune which has attended the carrying out of the act of 1862, this variety of plans and methods in the various States was the best.

Look at it for a moment. Of all men none has stamped more ideas into the thinking of this generation than has John Stuart Mill; but among all his thoughts regarding education I remember none more pregnant and original than one regarding systems of public education. It is that, with all its benefits, such a system has one great danger, and that is, its tendency to shape all minds by the same course of education into the same mould, thus preventing the fruitful collision and friction of mind with mind; thus bringing on a stagnant, barren sort of Chinese routine in thought.

Happily for us, by leaving these funds to each State for management, this evil has been avoided. And not only this, but almost every one of these institutions has found out something of use to every other. There is, indeed, unity between all, but not uniformity; and here let me say that having made it my business to look closely into the methods of all these institutions, and to visit and personally inspect many, in order to bring home what might be good for our own use, I can bear testimony that never have funds been more carefully applied and made to do more in furthering this great purpose.

I know every one of these institutions, and I know not one which is not making a noble return on all it has received.

No sooner was the bill passed than a multitude of colleges rushed forward to these legislative halls in a scramble for the fund. At one

time there were twenty institutions calling themselves colleges and universities of various religious denominations clamoring at Albany for a scrap of this endowment. As scrip was selling, the whole fund, had not an individual come forward to "locate" it, would have amounted to about \$600,000. Dividing this among the twenty, there would not have been enough money to give a single professorship to each.

This the Legislature of New York saw, and, despite the pressure from these institutions, it wisely determined not to fritter away the fund, but to concentrate it. It recognized the fact that for primary education the rule is diffusion of resources, but, for advanced education, concentration, and it wisely concentrated the fund upon an institution known as the People's College, at Havana.

The endowment was given to the People's College on certain conditions. Among them, it was required that the institution should have a certain amount of land, accommodations for a certain number of students, a Faculty of a certain size, a certain equipment, and that it should be free from incumbrance. A year went by, and these conditions were not complied with. Still the Legislature waited, and sturdily refused to yield to clamors for frittering away the fund. Another year went by, and still nothing was done; and, what was worse, it was discovered that a bill had been introduced to relieve the People's College of these conditions. At this, Mr. Ezra Cornell came forward and offered to pledge an endowment of \$500,000 to a new institution, provided the funds were transferred to it. A bill was passed chartering such a new institution; but, in order that full justice might be done the People's College, it was allowed three months to put itself in possession of such sum as the Board of Regents of the State should declare equivalent to compliance with the conditions of the original act.

The Regents, after full examination, fixed the sum at less than \$170,000. For nearly three years, then, that institution might have obtained the whole endowment had its friends, or had that locality, raised for it a sum of less than \$170,000. The time passed—they still did nothing. Mr. Cornell then came forward and redeemed his pledge; and thus was founded, for scientific, industrial, and general education, the Cornell University.

So much for the main features of the struggle toward the establishment of what has been called the "New Education" in the United States and the State of New York.

But what is this new education? I ask you to look first at its special purpose, and finally at its general scope. And, first among the special departments grouping themselves under such a system, I name the COLLEGE OF AGRICULTURE.

And here let me refer to a misapprehension, which should be corrected at the outset. For a typical example of this, I take up a paper read at the recent Educational Convention at Elmira, by the Rev. Dr.

McCosh, President of Princeton College. In that paper, the whole national and State policy regarding scientific and industrial education was condemned. The decision arrived at by two different Congresses of the United States, and by nearly thirty State Legislatures, the plan adopted by nearly thirty Boards of Trustees and Faculties in the various States—many of them after careful study of institutions at home and abroad—were dismissed with contempt. The main argument was, so far as argument can be detected among the multitude of assertions, that Scotland, from which the doctor had not long before emigrated, had got along well enough without any provision for agricultural instruction.

Never was there a more admirable illustration of the thoughts put forth by James Russell Lowell, on "a certain condescension in foreigners." To two institutions the doctor paid his respects by name, one being Rutgers College, in New Jersey; the other Cornell University. The first of these, Rutgers College, it would appear had committed an unpardonable sin. While the doctor's learned predecessors, at Princeton, had been preaching against "science falsely so called," the Rutgers College authorities had received that portion of the college land-grant fund which came to New Jersey, and had established an admirable school for applied science. This it was, doubtless, which led the doctor, in the heart of this State of ours which glories in its descent from the men who founded the Dutch Republic, to stigmatize his sister institution in New Jersey as "managed by a pack of Dutchmen."

His reference to the Cornell University was of another character, and not all my respect for the doctor's ability as a metaphysician will allow me here to suppress the fact that his whole argument was based upon one of the most astounding misrepresentations ever attempted upon an American audience.

This misrepresentation was in regard to the law of Congress of 1862. Throughout the doctor's address the idea is conveyed that the law of 1862 contemplated solely the establishment of exclusively agricultural colleges.

Nothing could be more wide of the fact. Had the doctor ever read that law he would have seen that, while "subjects relating to agriculture and the mechanic arts" were named as "leading branches," it was expressly declared in the act that other scientific and classical branches should not be excluded. Nay, more, he would have seen that so broad was the intention of Congress that the wording of the act is, that "subjects *relating to* agriculture and the mechanic arts" shall be taught, thus giving the authorities permission to extend their teaching into every field of learning which could strengthen these departments or elevate them.

I am aware that, in opposition to the plain intent of the act of 1862, the doctor may fall back upon its title, in which, for the sake of

brevity, only the leading objects of the colleges are mentioned; but, had he read even so accessible an exposition of law as Kent's "Commentaries," he would have found that every act is to be construed by its contents and not by its title.

But the doctor was especially hilarious over the small number of graduates from our agricultural colleges.

Let us look at this. The number is at present very small, but I presume that no thoughtful man expected that at so early a period after their establishment the number would be very large, nor, indeed, do I expect that for some years the number will greatly increase. In a new country like ours, those professions which present the most brilliant returns will be sought for first. Hence we find that, when a farmer decides to educate his son, it is not generally with the idea of making him a farmer. And, even when he does bring him up as a farmer, he has great doubts as to the value of any instruction for that purpose outside of the old farm routine.

But while I allow freely that this is the case now, I can state quite as confidently that this condition of things cannot continue for many years. There are those now living among us who will stand among a hundred millions of citizens within the boundaries of our Republic. When that day comes—nay, long before—this present condition of things must change. The present system of routine cultivation—this present system of "skinning" lands and then running away to soils more fruitful, in the intention of robbing and running away from them in turn—cannot last. Men must get a subsistence on less and less land; and they can only get it by bringing to bear upon it better and better cultivation. How soon we shall come to the division of property in the Scotch Lothians or the Belgian Pays de Waes, with their small farms exquisitely tilled, and supporting well a body of thrifty men, I cannot say; but the steady approximation to it is as inevitable as fate. And at the same time that this goes on, the professions hitherto known as "learned" will be more and more thoroughly filled. We see the beginnings of this now. Already is it becoming less and less easy for the farmer's boy to be sure that the little dark office in the great city block, swarming with lawyers, is, after all, so much more promising than the open fields and the work of the farmer.

And now, what should this industrial education be? Many men, hastily looking over the subject, have jumped to the conclusion that it should consist in simply teaching the plain arts of husbandry and of mechanics; that is, that the great object should be to train young men simply or mainly to hoe or spade or plough in the fields, or to make chairs or shoes, or hats or boats, in the shops. There could be no more wretched perversion of the trust imposed by Congress. The phraseology of the act of 1862 was chosen with great care, and, when it speaks of "branches *relating* to agriculture and the mechanic arts," it means just what it says. It meant to provide that all applicable

science be brought to bear on those arts. It meant to provide for the education of men who could develop them and improve them. Merely to add, to the millions now intelligently practising these arts, a few more intelligent farmers or artisans each year, would be a wretchedly inadequate return for these endowments. The places for imparting the simple, usual practical education for agricultural and mechanical pursuits are the millions of farms and workshops in the country. Nowhere else can such practical knowledge be afforded so cheaply or so effectively.

The national institutions for education should, indeed, have farms and workshops; but the foremost object of these should be, not to afford simple employment to young men, but to give them, in connection with their studies in the sciences, what may be called *laboratories*, where they can see science applied in as practical a manner as possible—laboratories, whether field or shop, where they can see sciences limited by the necessities of practice. It cannot be too much insisted upon that the main object of these institutions should be to send out men, with minds trained by observation and experiment, to develop the various agricultural and other industries, and to improve them, and not simply to increase, by an almost infinitesimal fraction, the number of those engaged in the usual industries pursued with a little more intelligence, in the usual way.

But it is said that scientific and industrial education does not better agriculture. Does it not? Of all assertions this is the most fearful indictment against the most extended field of human thought and work. If this be true, then is agriculture the only industrial pursuit unworthy of a human being; for this assertion would not be made against any other branch of human industry. But it is not true. The whole history of agriculture shows exactly the reverse of this. Look at those wonderful "Tables in Comparative Sociology," by Herbert Spencer, just issued, and study there the progress of agriculture and other industries from their rudest beginnings, and you see that skill in observation and reasoning on observation have been steadily improving agriculture, at the same time that they have improved other industries.

But grant that the number of students devoted wholly to agriculture is small, it is not these alone whose education tells upon agriculture. Even a partial course in it has great value. It was the remark of a very distinguished statesman of this Commonwealth—one who occupied this desk as Speaker, yonder chamber as Governor, and who received the suffrages of many of his countrymen for the highest office in their gift—that the main thing in agricultural education is to do something to make agricultural pursuits attractive. His view is that whereas in England every man longs to obtain a competency to enable him to retire from the city, here men seek to escape from the country to the city; and that we should attempt to bring about a change of

this sentiment in our educated young men. The author of that remark is Horatio Seymour. It struck me powerfully as sound and just, and, shortly after the establishment of the Cornell University, the trustees adopted a rule by which every student in every department—as a condition for graduation—must hear a course of lectures on general agriculture.

I am glad to state that, although the rule was received with some grumbling at first, that grumbling stopped immediately after the first lecture. Said a student to me at that time, "These lectures make us all wish to get hoes, and go at scratching up the ground at once." The lecturer for this general purpose is John Stanton Gould. May his interruption by ill health, which has deprived us of his service the past year, be but temporary! Long may he be spared to the University and the State, for whose good he has so steadily and so earnestly labored!

But suppose that no young men came forward to take agricultural studies, the new education would still tell powerfully on agriculture. Think you that we can send out year after year—as we did last year—a hundred graduates from all our various departments, whose powers of observation have been trained and whose real knowledge of subjects bearing on agriculture has been extended by close study in Botany, Animal Physiology, Geology, and Chemistry, without its telling ultimately on the progress of agriculture?

But suppose that not one student was even thus educated, I maintain that the State and nation would receive more than the equivalent of its endowment.

Look at a few figures. The last census gives certain agricultural statistics whose magnitude is almost oppressive. The value of farm productions in the United States, in the year 1870, was considerably over \$2,000,000,000.

The value of farm productions in the State of New York, the same year, was over \$250,000,000.

Does not common-sense tell us that we can well afford to make a little outlay to promote any sciences which may help such a vast interest? If in the course of years, in all these laboratories and experiments, some one useful idea shall be struck out, it would repay our endowments a thousand-fold.

Says Emerson, "The true poet is an inspired prophet." Did you ever think what an inspiration lies in the poet's declaration that "the greatest benefactor of mankind is he who makes two blades of grass grow where one grew before?" If not, look at the census returns showing the enormous value of the hay-crop of these Northern States.

Knowledge of Nature—coming by research and observation in the laboratory and the field—these are to give us finally our "two blades of grass," and multitudes of other benefactions to our race not less precious.

The Sheffield Scientific School at Yale College has not a single stu-

dent in agriculture, but Profs. Brewer and Johnson, by their experiments on fertilizers and kindred subjects, have returned the value of their endowment to the nation a hundred-fold already.

Take another item. The dairy products of New York in 1870 were over 100,000,000 pounds of butter, and over 20,000,000 pounds of cheese. Now, there has been quietly at work, in our Laboratory of Agricultural Chemistry at Cornell University, a young professor, Mr. George C. Caldwell. He has made little noise in the world. While Dr. McCosh was striking the stars with his lofty head, and his voice was shaking the Agricultural Colleges, this young man worked quietly on upon the chemistry of the dairy. Said Mr. L. B. Arnold, an authority you all recognize, "Prof. Caldwell's researches on the chemistry of the dairy are worth more to the State than your whole endowment. He has taught us to do such things in dairy matters and to increase dairy products as we never dreamed of doing." And to this, substantially, Mr. Arnold has lately sworn before the Commission of Investigation.

Take a few figures more from the same census. In 1870 the market-garden and orchard products of the State of New York amounted in value to close upon \$12,000,000.

Can any one, then, gainsay the wisdom of our employing, as we do, a young naturalist of genius to devote his whole time to investigations regarding insects injurious to vegetation, and to giving lectures based upon these researches?

Take still other figures. The same census shows the value of farm implements in the State of New York to be over \$45,000,000. In view of this we have investigations and lectures upon mechanics related to agriculture, and have obtained models and implements at home and abroad to illustrate this subject. Is not the mere pittance this requires well laid out?

I remember some years since seeing a paragraph going the rounds of the papers, stating that President White had sent from Europe to Cornell University an Oxford professor and a horse-doctor. The charge was true. The Oxford professor was Goldwin Smith; "the horse-doctor" was Prof. James Law, formerly of the Royal Veterinary College at London. Each one of these men, in his way, has been a blessing to the University and to the country. But look at a few more figures from the census. The number of horses in the State of New York is over 800,000; the number of neat-cattle exceeds 2,000,000. Prof. Law's lecture-room is one of the most attractive places I know, for animal physiology is a study worthy of any man, but, even if he never taught a student, in view of this vast interest is it not well worth while to provide such a man to investigate such a subject?

Take another branch. We have been fitting up an establishment for experiments in the best rotation of crops and in the feeding of cattle. A careful and resident professor has been called to carry on

these, and I trust that Mr. E. W. Stewart may be called to superintend them.

Some time since, in view of this matter, I visited certain cattle-feeding establishments with a gentleman whose sound sense on such matters you all recognize, Hon. George Geddes. Said he: "This experiment, fairly tried, will be worth to the State of New York more than your whole endowment, no matter which way it turns out—no matter whether 'soiling' is found profitable or unprofitable; to try this matter fully, and fairly, and scientifically, will be worth more than your endowment."

The act of 1862 also provides with special care for instruction in "BRANCHES RELATING TO THE MECHANIC ARTS."

If you doubt the wisdom of this, look again at the last census. There you find the manufactures of the United States valued at \$4,000,000,000, and over 2,000,000 persons engaged in them. Can education be made useful to this vast interest? Other nations think so, and are laying out vast sums in this direction. Some of our sister States are doing admirably in this respect. Illinois and Massachusetts have made excellent provision for mechanical science, and the recent message of Governor Bagley, of Michigan, shows that good work is to be done in that State. In an address delivered before this Society a few years since I described some of those foreign institutions. I trust, then, that you will pardon me for describing that which we have since created in this State.

Thanks to one of our trustees, a noble provision has been added for this purpose to that originally made by the nation.

The Hon. Hiram Sibley, of Rochester, has erected a building, equipped it with lecture-rooms, draughting-rooms, a workshop supplied with the best machinery, and has given an endowment to support a Professor of Mechanical Engineering and a superintendent of the machine-shop. Besides this, Mr. Cornell has erected a shop for wood-working, and has provided water-power for both establishments.

What is the system? Young men come wishing to make themselves first-class mechanical engineers or master-mechanics, or to perfect themselves in any branch of mechanical industry. Under careful instructors, they are carried through the various sciences bearing on their profession. They are taught mathematics in all their relations to mechanics. In one room they go on with the mathematical and mechanical drawing of machinery, in another with free-hand drawing; in the laboratory they are taken through various processes bearing upon their profession. A certain number of hours every day they must give to the workshop, and there, in well-worn apron and rolled-up sleeves, they go on under careful supervision from the use of the simplest machinery and the plainest work to the most complicated. The purpose is to send out every year a body of young men with not merely a very high grade of theoretical instruction, but with most thorough

practical instruction—men who cannot merely calculate the size of parts of a machine, but who can draw it after they have calculated it, and make it after they have drawn it. These are the men whom our country sorely needs to complete the organization of its great army of industry. Indeed, I know of no more pressing material need in this country. Our land has more mechanical ingenuity in it than any other; but did you ever think of its wretched misdirection and waste for want of industrial education? If not, stroll through the national Patent-Office. Look at a few facts. In one of our most important cities are engines for supplying that city with water—erected at vast expense. The whole amount was wasted. There is ingenuity in that vast machine, there is skill in it; but, for want of education regarding certain principles involved, the whole thing is failure and waste.

Take another case. A few years since, with a small party of our fellow-citizens, I visited the West Indies in a national ship. She was a noble vessel, and her engines had cost, it is said, nearly \$800,000. The engines showed ingenuity; but they were so deficient in proper elements of construction that our voyage was prolonged until we were all given up as lost and had the honor of having our obituaries in the leading newspapers! The first voyage of those engines was the last. They were sold for old iron; and the sum lost on them alone was sufficient to endow the finest institution for mechanical engineering in the world! I might multiply examples of this sort, but this is enough to show what need exists for more careful training in this direction, and I pass to a kindred department.

Another great department bearing on a multitude of industries, directly and indirectly, is *CIVIL ENGINEERING*. Take one among the fields of its activity. We have in the United States about seventy thousand miles of railway, and every year thousands of miles are added. I do not at all exaggerate when I say that millions on millions of dollars are lost every year by the employment of half-educated engineers. Proofs of this meet you on every side. Lines in wrong positions, bad grades and curves, tunnels cut and bridges built which might be avoided. All of us know the story.

But this is not all. Hardly a community which has not some story to tell of great losses entailed by bad engineering in other directions. I have known the traffic of a great city street interrupted for a year, because no engineer could be found able to make the calculations for a "skew arch" bridge, a thing which any graduate of a well-equipped department of engineering can do. I have known a city subjected to enormous loss by the failure of its water-supply system, because the engineer employed made no calculation for the friction of water in the pipes. I know a whole district sickened by miasma, because a half-taught engineer was intrusted with its drainage. We must prepare men for better work; and, for every dollar thus laid out, we shall create or save thousands.

Take next, then, **SANITARY ENGINEERING**. Science has, within a few years, made wonderful strides in revealing the origin and propagation of disease. The summaries recently made by President Barnard, Prof. Dalton, and Prof. Chandler, give an admirable view of this conquest. Mr. Baldwin Latham, in his recent book on "Sanitary Engineering," gives careful tables, showing the enormous reduction of consumption, typhus, and typhoid, in several English towns by the application of science to sewerage and water-supply. Dr. Beale, in his work on "Disease-Germs," shows by statistics that a proper application of engineering to sewerage would save 100,000 lives yearly in Great Britain. More and more is this matter becoming important in this country. Hardly one in twenty of our towns has any well-adjusted system of sewerage or water-supply, and in our rural districts vast tracts are made wretched by miasma.

Nor is this probably the worst. Vicious systems of heating and ventilation are probably doing more to break down the physical constitution of our people than all other causes combined. We see it everywhere in sickly women, and puny children, and men but half alive. The study of human physiology and the system of preventing and removing disease-germs should be combined, and young men should have the opportunity to fit themselves for grappling with the problems presented to sanitary engineers.

Few among us dream of the monstrous waste now entailed upon this country by imperfect instruction in **MINING ENGINEERING** and metallurgy. Take first the losses by fraud. A few years since our people were asked to invest in a Nevada mine of great richness. Half-educated mining geologists had certified to its value. But certain capitalists sent a young man, carefully educated in a scientific school, to examine and report. The young man on arriving found that the mine looked well enough, but on applying more scientific tests he found that an old worthless mine had been taken; that rich sulphurets had been brought and carefully placed in it at a cost of probably \$100,000. His report exploded the fraud, and nearly \$1,000,000 was saved—more than five times the sum that this scientific school received from the Government of the United States. This same gentleman also exploded a great diamond-mine fraud of the same sort.

Take another case. Not long since a party of gentlemen determined to invest several hundred thousand dollars in working certain iron-mines in this State. Just before their arrangements were finally made, and much against the will of many of the proposed stockholders, a young graduate of one of the scientific schools which received the national endowment was sent to make an examination. He found that the veins contained titanium, and that the entire investment, should it be made, would be lost. His fee was \$250; he prevented a loss of over \$400,000.

You see now why Pennsylvania and Missouri and California and

Massachusetts are aroused as to this matter also, but you will perhaps say that New York is but little interested here. Look again at the census, and you will see how wretchedly you are mistaken. The value of the mining products in New York in 1870 was more than half that of the entire gold product of California. Here, too, we must follow up the good work begun by our Chandlers and Raymonds.

Look next at **CHEMISTRY APPLIED TO MANUFACTURES**. More and more the chemical laboratory is becoming a great central point in industrial education. Run over but two or three points out of many. A chemical discovery in coloring-matter has given us a substitute for madder, and restored the great area given to cultivation of that material to the increase of material for human sustenance. An apparently trivial application of another chemical principle has enabled Onondaga to purify its product so that it now competes with the world in the purity of its salt for the dairy. Another application has enabled another part of the State to make quantities of steel formerly undreamed of. And all this is but the beginning of the applications of chemistry to increase the well-being of the State and nation.

We must also make provision for instruction in **ARCHITECTURE**. Wealth and public spirit—individual and municipal—are now erecting myriads of costly buildings in all parts of our country. The number of uneducated architects is very great—the number of thoroughly prepared architects is very small. Have you ever considered the waste attendant upon this? Every month you hear of some architectural failure that costs life and treasure. To-day it is a church-floor which gives way, and a multitude of children are taken from the ruins mangled and dead; to-morrow it is a whole city quarter swept away by fire, because some half-taught architects knew no other way of producing architectural effect than by piling up combustible ornaments on inaccessible roofs.

Nor is that all. Our people are laying out millions on millions in buildings which within thirty years—in the advance of taste and knowledge—will be eye-sores and must come down. A building erected by a true architect will grow more beautiful for hundreds of years. A building erected by a sham architect will be an incubus in a quarter of a century. People are beginning to see this, and we are endeavoring to prepare men thoroughly to know the best materials, to calculate their strength in construction, and to combine material and construction according to everlasting laws, and not according to some pretty present fashion; and this is the purpose of our School of Architecture.

Look now at instruction in **DRAWING**. The casual visitor to an institution like that established in this State will often say something like this: "I can understand the value of your libraries, collections in natural history, apparatus, models, shops, and lecture-rooms; but what is the use of your great draughting-rooms?"

If I answer that drawing is taught in one for civil engineers; in another for mechanical engineers; in another for architects; in another free-hand drawing for all these together, he will say: "Why teach free-hand drawing at all? That is rather artistic than industrial."

Is it? Look at a few recent facts. A few years since the State of Massachusetts passed a law requiring free-hand drawing to be provided for in the public-school system throughout the State. The city of Boston did the same. State and city combined to call, from the great English school for industrial art at South Kensington, Mr. Walter Smith, at a salary of \$5,000, to direct the schools of that city and State.

Mr. Smith has worked on, and the result is that already this instruction has been admirably developed. Now, why has this been done? Has the State of Massachusetts, which we have always known as so thoughtful in its legislation and education, really fallen into mere dilettanteism? Not at all. Look at a few more figures from the census.

In 1870 the product of Massachusetts in printed cottons was over \$17,000,000, and her product of other goods into which the arts of design enter as a matter of first importance was doubtless even more. Massachusetts is thoughtful as ever. She sees that other States are overtaking her in manufactures so far as quantity and quality of material are concerned, but she determines to distance them by spreading throughout her borders knowledge of the principles of beauty in design and skill in them. And she never did a wiser thing. It will tell on a multitude of industries. Why do we import such vast quantities of English, German, and Danish glassware and pottery?—because they are better in material than ours? No; but because they have a beauty in design which leads the most illiterate to choose them. Why do we import such quantities of silks and carpets and chintzes and wall-papers from France? The Cheneyes make silks as good in quality on this side of the ocean as the Compagnie Lyonnaise make on the other; the Bigelows make carpets just as good in material here as the D'Aubusson factory makes there; and yet, when our wives and daughters see these foreign fabrics, they immediately prefer them. Why? Simply because there generally are in the foreign product a skill, a beauty, a taste in design, that appeal to that sense of beauty which God has implanted in the rudest of our race.

Other nations in this warfare of industry see this. England is devoting millions to art education, in order to keep up her manufactures, and it has established in the Privy Council a science and art section to direct this expenditure wisely; Germany is doing even more; France has been doing it for generations, and it has given her the supremacy thus far in a multitude of branches of manufacture.

If you wish to see how these nations have done and are doing this, look at Mr. Stetson's admirable little book on "Technical Education."

You will there see that Prussia alone gives industrial education in various branches to over 11,000 men. If you wish to see how public-spirited individuals have done this, visit the draughting-rooms of the Cooper Institute, and Worcester Institute, and Lafayette College.

Already the value of this is known to our manufacturers. Mr. Stebbins tells us that one silver-ware establishment in the city of New York pays a graduate of one of these foreign schools, for making designs and patterns, as high a salary as our Empire State gives its Governor.

But it may be said, "The French are naturally artistic; our people are not." But, look at history; see how it disposes of these short and easy excuses for doing nothing. The French are descended, on one side, from the most unartistic nation of antiquity, and on the other from painted barbarians. As to the former, one of their greatest poets boasted that his fellow-Romans could tyrannize over the world, but had no capacity for art. As to the latter, Guizot, one of the greatest of statesmen and historians, shows that the barbarian ancestors of the French had the same fundamental ideas as American savages.

When our ancestors were savages, their ancestors were savages. It is only a few generations since, if they wished for good artistic work, they had to send to Italy for it. The French are "naturally artistic" because Liancourt, and other patriots like him, began, a hundred years ago, to create those great systems of education—scientific, industrial, and artistic—which have given the French almost the monopoly in supplying products of skill and beauty to the markets of the whole world.

To complete the system provided by the great congressional act of 1862, it was declared that instruction in *MILITARY TACTICS* shall also be included.

Not least among the evidences of statesmanship in that bill was this last clause. The idea it embodies has been too long neglected. Of all fatal things for a republic, the most fatal is to have its educated men in various professions so educated that, in any civil commotion, they must cower in corners, and relinquish the control of armed force to communists and demagogues. The national colleges have carried out this part of the act, sometimes by giving advanced military instruction, but generally by careful drilling of the whole body of students. The system has been found to give health and manly dignity to the student; to the nation it is to give a great body of well-trained men, ready to organize and control the best elements of society against any outbreak of anarchy or treason.

And now a few words regarding the general education which goes with these various branches of industrial and scientific education. The student must be not only trained as a specialist, he must also be educated as a man and a citizen. Hence the necessity of blending into the various special courses certain general studies calculated to

give breadth and foresight and insight. Among these I name, first, instruction in **HISTORY AND POLITICAL SCIENCE**.

On this subject, the "new education" lays stress, and especially on the history of our own race and country. The subject has been sadly neglected; but more and more it is seen that, to train men to build up the future, we must show them with what successes and failures their predecessors have built up the past.

Thought, too, should be stirred on the more pressing problems in **SOCIAL SCIENCE**, and among them the best methods of dealing with pauperism, crime, insanity, sanitary management, and public instruction. Foundations for study on these might, at least, be laid, and right direction given to those whose tastes turn toward participation in public affairs.

No thoughtful man will deny that it is well to give even to students in industrial branches access to the best thoughts of the best thinkers—the study of the great languages and **LITERATURE** does this—and especially is it done by the study of this wonderful language and literature of our own.

Another most important means of discipline and culture is to be found in the study of **THE NATURAL SCIENCES**. On these much of industrial and general progress depends. They discipline the power of observation, and reasoning upon observation. They give, too, a culture to the sense of beauty in form, and fitness in adaptation.

But I am aware that objection is made to the study of Natural Science on the ground of a dangerous materialistic tendency.

But can this objection be well founded? Among the many striking passages in Herbert Spencer's "Treatise on Education" is one of special interest on this point. He asks, what would any author think were a person to come into his presence, praise his works, and dwell upon their beauty and perfection, when the author knew that this flatterer had never read a single page, or even a single line, of them? And what, then, must the Great Author of all things think of one who thus comes into his presence, extols his works in all moods and tenses, the Great Author knowing that this flatterer has never studied out a line in the great book of Nature—nay, that he has discouraged others from studying it? I come now to certain **GUIDING IDEAS**—necessary in carrying out any worthy system of scientific and industrial education.

1. Of these I name **UNSECTARIANISM**. Our own charter makes "men of all sects and parties, and of no sect or party, equally eligible to all offices and appointments." For this, some good men have thought it their duty to denounce us from pulpit and press as "godless;" but it has proved our salvation. It has enlisted benefactors of every creed. That it has taken strong hold upon the people is shown by the millions given the institutions on this basis, and by the steady support of these despite all calumnies. There is no other possible basis for the development of great institutions for scientific and indus-

trial education. To confine their choice of professors to any one denomination, or circle of denominations, is to dwarf them; to put them under control of any synod, conference, association, council, or convention, is to strangle them.

2. I name FREEDOM OF CHOICE BETWEEN VARIOUS COURSES OF STUDY. The old way in the more venerable colleges and universities was, to force all students through one single classical course—the same for all. This system the “new education” discards. General courses in literature, science, and arts, are presented, as well as special courses having reference to the great industries; and the student, with the advice of friends and instructors, takes that which best suits the bent of his mind. We believe that the results are already better than those of the old system. Certainly they could not be worse. The famous “Blue-Book of the Parliamentary Commission” on advanced education, in England, shows that under the old system there seventy per cent. of the students in their great schools and universities take no real hold upon classical studies. Few will claim that our system of classical instruction is better than that in England. If any of you think it more promising, look at President Barnard’s cogent statistics on this point. We make no opposition to classical instruction. We agree that, for those who take earnest hold of it, it is one of the noblest means of discipline and culture; but it is no less evident that for those who do not take hold of it—who merely “drone” over it—it is one of the worst.

3. I name EQUALITY IN POSITION AND PRIVILEGE BETWEEN DIFFERENT COURSES OF STUDY. I have already shown how courses of study in science, and especially those bearing on industry, have been held, in various places, virtually inferior to courses of study in literature. Against this we stand pledged. We are determined to hold all courses and all students as equal; educating them together, graduating them together, welcoming them back as alumni together. But the “new education” does not merely endeavor to give a greater range of studies, it seeks also to improve METHODS. Let me mention two of these:

1. I name the BETTER USE OF THE LECTURE SYSTEM. Those who knew Louis Agassiz well will never be at a loss to recall conversations, instructive and entertaining; but I think that, among them all, none conveyed a better mixture of philosophy and fun than his delineation of the recitation of text-books by rote, as it has been so long practised in our American colleges. No system was ever better calculated to deaden enthusiasm and stiffen knowledge. More and more we are coming to see that, wherever possible, we must bring the living mind to bear on the student. Thus may we supplement text-books, and take from them their present woodenness and dreariness.

2. I name THE UNION OF STUDY OF THINGS WITH STUDY ABOUT THINGS. Under the old system it was book in the morning, book in

the afternoon, book in the evening—an unceasing round of studying what men have said *about* things. Under the better system of the various institutions for scientific and industrial education, the student passes frequently from study about things to study of the things themselves, in laboratory or workshop, in draughting-room or museum, or in the field. Every science must now have its laboratory practice, and thereby are given to lectures and recitations reality and interest. Thereby is gained ability to bring theory to bear upon practice.

But an objection of another sort is raised. It is said, "Why give instruction in classical branches at all?" I answer, for three reasons: 1. Because the act of Congress declares expressly that they shall not be excluded. 2. Because to those who wish them they are an excellent means of culture. 3. Because we wish to avoid that old mistake of separating industrial and scientific students from classical students. Heretofore students in science and technology have been banished to some little special college in some remote corner of a town or State, while classical students have had all the prestige arising from connection with large and thoroughly equipped institutions. We stand upon the principle of considering one student the equal of another—the student in science and industry the equal of the student in classics. We stand against any separation which shall serve to perpetuate that old subordination of men in the new education to men in the old.

But it is objected that the new system does not provide for mental discipline. Never was a charge more absurd. Discipline comes by studies that take hold of a man, and of which he takes hold. Is it not evident that the new system, which adapts studies to the tastes and aims of men, is more sure to take hold and be taken hold of than the old system, which grinds all alike through the same processes and studies?

But it is said, "Why concentrate your resources in one institution?" I answer, because that is the only way in which you can ever have the work done. To erect, equip and maintain laboratories, workshops, farms, collections, libraries, observatories—all this demands great sums.

To have such institutions, you must pay the price. While the rule, as already stated, regarding preliminary public instruction, is to distribute resources, the rule in regard to advanced education—scientific, general, or industrial—is to concentrate resources. Look at it. The last report of the Bureau of Education shows in the United States 397 institutions called colleges or universities, and you can count on the fingers of your hands all those worthy of either name.

Wisely, then, have the great States refused to yield to clamors for scattering or frittering away these funds. Wisely have individuals poured out their wealth to supplement them.

To the institution in our own State already over \$1,500,000 have been given by individuals, and I trust that this is but a beginning.

Do you say that this endowment may be too large? Compare the endowment for the increase of intellectual wealth with any one of a thousand endowments for the increase of material wealth. Look at the hotels of your great cities. Some of them have cost more than the entire outlay in buildings for advanced instruction throughout whole States.

But it may be said, "Why not devote all your resources to agricultural experiments and instruction?" I answer—1. The law of the United States does not allow it. 2. Because in the interest of agriculture itself we should educate men to develop other industries. What is the great want of our Western States at this moment? Greater agricultural production? No. What they want is, the development of great and varied manufacturing industries, so near them that it shall no longer take two-thirds of a bushel of corn to carry the other third from producer to consumer.

And, finally, it is objected to the "new education" that it is godless. There is nothing new in this charge. It has been made against every great step in the progress of science or education. And yet it has certainly been found that although ideas of religion are changed from age to age, the change has tended constantly to make these religious ideas purer and nobler. The majority of the Fathers of the Church held the new idea of the rotundity of the earth incompatible with salvation. Martin Luther thought Copernicus a blasphemer for his new idea that the earth revolves about the sun, and not the sun about the earth. Dean Cockburn declared the new science of Geology a study invented by the devil, and unlawful for Christians. When John Reuchlin and his compeers urged the substitution of studies in the classics for studies in the mediæval scholastic philosophy, their books were burned, and they themselves narrowly escaped the same fate.

No, my friends; every study which tends to improve the industry of mankind makes a man nobler and better. Every study which gives man to know more of the history of his race, gives him to see more and more clearly the finger of Providence in history; every study which brings his mind into contact with the thoughts of inspired men as exhibited in our literatures, builds up his manliness and his godliness, and every study which brings him into close contact with Nature in any of its fields not less surely lifts him "through Nature up to Nature's God."

I have thus sketched very meagrely the growth thus far of the "new education." Its roots are firm, for they take fast hold upon the strongest material necessities of our land; its trunk is thrifty, for it is fed by the most vitalizing currents of thought which sweep through our time; nay, the very blasts of opposition to this growth have but strengthened it; the winter of discontent through which it has passed has but toughened it; and in agriculture and every branch

of industry; in every science and art which ministers to either; in all the development of human thought which is to make men better and braver, it is to bear a rich fruitage for the State, for the nation, and for mankind.

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THE POPULAR SCIENCE MONTHLY,

(Established May, 1872.)

Conducted by Prof. E. L. YOUNG.

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